AFOSR-TR- 86-0815

(2)

RF Project 764977/717636
Quarterly R & D Status Report

STRENGTH AND STRUCTURE OF $GA_{1-x}IN_x$ AS ALLOYS

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Strength and Structure of $Ga_{1-x}In_xAs$ Alloys

Quarterly R & D Status Report

July 15, 1986

ARPA Order 5526

Program Code 5Y10

Contractor: Air Force Office of Scientific Research

Contract Dates: September 1, 1985 - August 31, 1986

Contract Amount: $142,286

Contract Number: F49620-85-C-0129

Co-Principal Investigators:
Katherine T. Faber and John P. Hirth
(614) 422-2960 and (614) 422-0176

Program Manager:
Captain Kevin Malloy
(202) 767-4984

The strengthening effect of gallium arsenide by indium additions is under examination. Interpretation of high temperature hardness results of In-free and In-containing GaAs suggests that the intermediate temperature hardening of these materials may be sufficient to reduce dislocation densities by two orders of magnitude during growth. The third quarterly report describes the most recent mechanical tests in this study to better understand the solid-solution strengthening in these systems.

(1) Progress

In the previous report, hardness measurements on undoped and In-doped GaAs wafers were reported. Conversion of these data to critical resolved shear stress values show that the values are in the same range as those experienced by the crystal during growth. The strengthening at higher temperatures with In addition is consistent with solution hardening being responsible for dislocation density reduction in In-doped GaAs. Based on these results, a manuscript was submitted to the Journal of Applied Physics in May.

The discrepancy between the present measurements and those reported by Swaminathan and Copley (1975) and Tabache (1985) were postulated to be due to boron concentration. Boron levels in our samples were found to be 7 ppm by weight (2×10^{18} atoms/cm^3) by spark source mass spectrometry. However, hardness measurements on GaAs wafers from Texas Instruments containing 1 ppm B and from Rockwell International containing less than 0.1 ppm B showed no significant difference in the hardness values from room temperature to 700 ^{o}C compared to the 7 ppm B-containing materials.

Compression test fixtures were assembled and a trial test using a (111) Si crystal was carried out at 750^{o}C. The fixtures work to our satisfaction. Specimens of GaAs for compression testing were cut from seed

crystals and polished, taking special care to maintain planarity of the end faces.

(2) Major Experimental Equipment Purchased

After the analysis of high temperature hardness data, it was found that the temperature range for compression tests should approach 1200°C to best evaluate any change in deformation mechanism with temperature. The current experimental facilities were not found to be adequate for the high temperature compression testing. The furnace which surrounds an environmental chamber containing the compression fixture had a maximum temperature capability of 1000°C but showed very slow heating rates above 800°C. A new Applied Test System furnace was ordered and should be in place during the first week of August.

(3) Changes in Key Personnel

None.

(4) Substantive Information Derived from Meetings

During the third quarter of this contract, contacts were made with the Electronics Research Branch of the Wright Avionics Lab. Dennis Walters of Device Growth and Characterization has been able to support us with GaAs containing low boron concentrations (approximately 1 ppm and 0.1 ppm) described earlier. Since the hardness testing requires little material, plans were formulated to continue interaction with this group at Wright Patterson in further characterization of the III-V materials.

Professor Jack Furdyna of Purdue University visited and toured our facility on June 13, 1986. Discussions involved mechanical characterization of the II-VI compounds, particularly the $Cd_{1-x}Mn_xTe$ system which can be fabricated nearly across the entire CdTe-MnTe binary. Studies

on II-VI compounds will be included in future studies if approved.

(5) Problems of Concern

Visa problems as well as personal problems have slowed the arrival of our second post-doctoral research associate, Dr. Ragnaw Rai, who is currently at Lawrence Berkeley Laboratory. His visa application is now with the Immigration and Naturalization Service; however he has been performing some microscopy on the GaAs crystals at the National Center for Electron Microscopy at LBL.

(6) Fiscal Status

(a) Amount currently provided for contract: $142,286

(b) Expenditures and commitments to 6/31/86:

(c) Amount needed to complete work:

(d) Estimated date of completion: 8/31/86

RET10 RETF10C PROJECT FINANCIAL SUMMARY SYS DATE 7/10/86 TIME 14:58:50
OPTION: 01 KEY: 717636 PROJ 717636 MPN 764977 MONTHLY DATA AS OF: 6/30/86
PI KATHERINE T FABER DEPT AF OFC SCI RES SD 9/01/85
COPI JOHN P HIRTH 1420 F49620-85-C-0129 ED 8/31/86
WKSTN 4 RPN 060006 DO WOODY PA VENTRESCA IDC G 44 45.00

DESCRIPTION	BUDGET	EXP MONTH	EXP TO DTE	COMMITMENTS	UNEN BAL
SPONSOR					
S & W -REL	10445.00	721.32	9368.92	255.55	820.53
S & W -RTY	55750.00	2971.45	21348.07	3558.66	30843.27
FRINGE-REL	1965.00	135.46	1694.60	35.03	235.37
FRINGE-RTY	12268.00	442.14	3158.46	498.21	8611.33
*TOT PERS	80428.00	4270.37	35570.05	4347.45	40510.50
REPORTS		17.94	125.71		125.71-
PURCHD SRV	1000.00		1460.60		460.60-
SUBCONTR	2000.00				2000.00
MAT & SUPP	12500.00	44.22	1614.81	2358.43	8526.76
OTHER D/C	200.00	21.76	460.23		260.23-
EQUIP PUR				7885.00	7885.00-
TRAVEL-DOM	2000.00		1519.75		480.25
*TOT DIR	98128.00	4354.29	40751.15	14590.88	42785.97
IND COSTS	44158.00	1959.43	18338.01	3017.65	22802.34 +

CSG% .00% OSU% .00% CSG$ OSU$ TOT$ 59089.16

RET10 RETF10C PROJECT FINANCIAL SUMMARY SYS DATE 7/10/86 TIME 14:58:50
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DESCRIPTION	BUDGET	EXP MONTH	EXP TO DTE	COMMITMENTS	UNEN BAL
**TOT SPON	142286.00	6313.72	59089.16	17608.53	65588.31

CSG% .00% OSU% .00% CSG$ OSU$ TOT$ 59089.16

RET13 RETF13C SYSTEM DATE: 7/10/86 TIME: 14:59:06
OPTION: 11 KEY: 210 717636 MONTHLY DATA AS OF: 6/30/86

OSURF TRANSACTIONS DISTRIBUTION SUMMARY

GENERAL LEDGER #: 210 SUBSIDARY ACCOUNT NO: 717636

COST CODE	OPEN ITEM	TRN CDE	SOURCE REF #	CAN NUMBER	TRANSACTION DESCRIPTION	COST EXP AMOUNT	SPONR EXP AMOUNT
100	337500	90	L60001		JUN 16-30,86-MON-BASE SA		711.73
102	288263	90	L60001		JUN 01-30,86-MON-BASE SA		2160.00
110	337500	90	L60001		JUN 16-30,86-MON-RETIREN		99.64
112	288263	90	K60001		MAY 86 LTD CHRG 81082387		3.92
112	288263	90	K60001		MAY 86 INS CHRG 81082387		22.18
112	288263	90	L60001		JUN 01-30,86-MON-RETIREN		296.14
130	223665	90	L60001		JUN 01-15,86-REL-BASE SA		600.00
132	907660	90	L60001		JUN 23-30,86-REL-BASE SA		31.68
132	907660	90	L60001		JUN 01-22,86-REL-BASE SA		89.64
140	223665	90	L60001		JUN 01-15,86-REL-INS ACC		20.90
140	223665	90	L60001		JUN 01-15,86-REL-RETIREN		84.00
142	907660	90	L60001		JUN 23-30,86-REL-RETIREN		4.34
142	907660	90	L60001		JUN 23-30,86-REL-INS ACC		3.48
142	907660	90	L60001		JUN 01-22,86-REL-RETIREN		12.29
142	907660	90	L60001		JUN 01-22,86-REL-INS ACC		10.45 +

CMD 5 = BROWSE BACKWARD ROLLUP
CMD 7 = BROWSE FORWARD ROLLDOWN

RET13 RETF13C SYSTEM DATE: 7/10/86 TIME: 14:59:12
OPTION: 11 KEY: 210 717636 MONTHLY DATA AS OF: 6/30/86

OSURF TRANSACTIONS DISTRIBUTION SUMMARY

GENERAL LEDGER #: 210 SUBSIDARY ACCOUNT NO: 717636

COST CODE	OPEN ITEM	TRN CDE	SOURCE REF #	CAN NUMBER	TRANSACTION DESCRIPTION	COST EXP AMOUNT	SPONR EXP AMOUNT
162		80		004172	PR0102 CIVIL ENG 5/86		66.48
162		80		004293	PR0104 CIVIL ENG JUNE 86		33.24
172		80		004173	PR0102 CIVIL ENG 5/86		13.51
172		80		004294	PR0104 CIVIL ENG JUNE 86		6.75
					TOTAL PERSONNEL SERVICES		4270.37
316		90	L60011		STORES CHARGES - JUN 86		44.22
344		80		021218	IB1543 TELE SERVICE 5/86		7.76
454		90	L60830		JUN REP CST CHGS		17.94
536		80		057535	FEDERAL EXPRESS		14.00
					TOTAL MATERIAL & SERVICE		83.92
840		90	L60004		COMPUTED IND-COST JUN 86		1959.43
					TOTAL INDIRECT COST		1959.43
					TOTAL FOR PROJECT		6313.72

CMD 5 = BROWSE BACKWARD ROLLUP
CMD 7 = BROWSE FORWARD ROLLDOWN

RET12 RETF12C PROJECT NUMBER: 717636 SYSTEM DATE 7/10/86 TIME 14:59:33
OPTION: 07 KEY: 717636 MONTHLY DATA AS OF: 6/30/86
PRINCIPAL INVESTIGATOR NAME: KATHERINE T FABER ADM NAME VENTRESCA
CO-PRINCIPAL INVESTIGATOR NAME: JOHN P HIRTH DO NAME WOODY

OUTSTANDING COMMITMENTS

COST CODE	PO-TA NUMBER	APPT LTR	PO-TA DATE	VEN/EMP NUMBER	VENDOR/EMPLOYEE FIRST NAME	C/S COMMIT AMOUNT	SPON COMMIT AMOUNT
100	337500	P	9/15/86	337500	JOHN P HIRTH		3558.66
110	337500	P	9/15/86	337500	JOHN P HIRTH		498.21
132	907660	B	8/31/86	907660	LAUREN RAE WERLING		255.55
142	907660	B	8/31/86	907660	LAUREN RAE WERLING		35.03
					TOTAL PERSONNEL SERVICES		4347.45
316	477850		3/18/86		KISTLER INSTRUMENT CORP.		1578.43
316	481888		6/06/86		ELLIS CERAMTEK, INC.		330.00
316	482686		6/24/86		STRUERS, INC.		325.00
316	482766		6/25/86		ALDRICH CHEMICAL CO INC		125.00
					TOTAL MATERIAL & SERVICE		2358.43
614	482806		6/25/86		APPLIED TEST SYSTEMS INC		7885.00
					TOTAL EQUIPMENT		7885.00
					TOTAL FOR PROJECT		14590.88

CMD 5 = BROWSE BACKWARD ROLLUP
CMD 7 = BROWSE FORWARD ROLLDOWN